Field Crop Spraying - *Engineering* for Drift Mitigation

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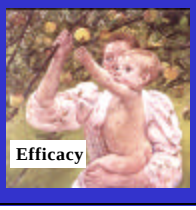
The application triangle



The holy triangle of application:

⇒ **Efficacy**
- **Penetration, deposition and coverage**

⇒ **Drift mitigation**
- **Prompt movement into the canopy with energy for deposition**

⇒ **Efficiency for the applicator**
- **Low volumes, high speeds, wide range of control**

The design challenge:

⇒ **Quality of the application job**
- Efficacy and reliability - speed, rate, conditions
- Mitigation of off-site movement - drift, run-off

⇒ **Provide a quality job**
- Active control of application - input / output

⇒ **Document the application**
- GPS / GIS mapping of the process

Drift Mitigation

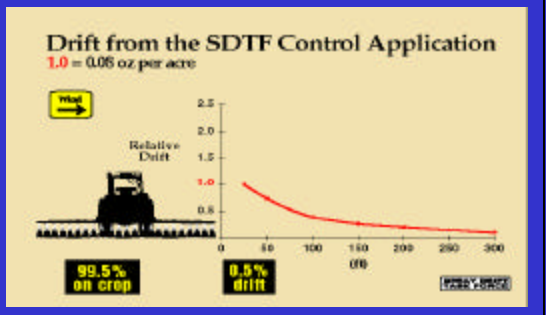
Requires that the spraying process be understood.

Requires that the applicator's situation, demands and likely response be understood.

Drift is caused by:

Droplets that:

- **are not deposited within the target canopy,**
- **are highly mobile,**
- **do not contribute to efficacy.**



The "classic" drift curve (nonstandard presentation)

Drift mitigation
(Giles, 2001)

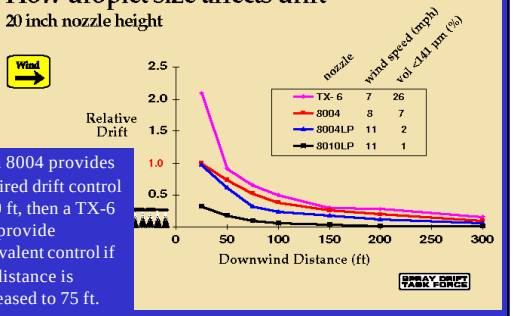
A rational, workable choice of proven conditions and compromises that achieve:

the desired drift reduction

while

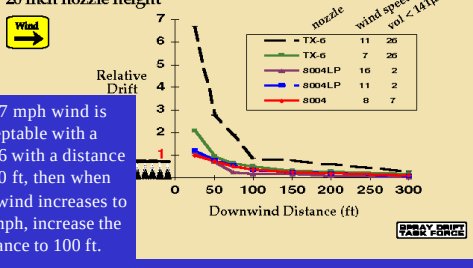
maintaining efficacy, responsible rates and productivity.

How droplet size affects drift
20 inch nozzle height



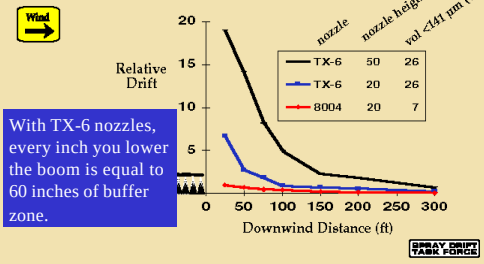
If an 8004 provides required drift control at 50 ft, then a TX-6 can provide equivalent control if the distance is increased to 75 ft.

How droplet size and wind speed affect drift
20 inch nozzle height



If a 7 mph wind is acceptable with a TX-6 with a distance of 50 ft, then when the wind increases to 11 mph, increase the distance to 100 ft.

How nozzle height affects drift
TX-6 nozzle



With TX-6 nozzles, every inch you lower the boom is equal to 60 inches of buffer zone.

Models of drift?

* **Powerful, robust tools to estimate potential drift and effects of mitigation options**

***IF** **they fully account for all aspects of the spray droplet transport process** **AND** **mitigation.**

***BUT** **they must be validated with proper experiments.**

Prime factors for spray drift:
(Holterman, et al. 1997)

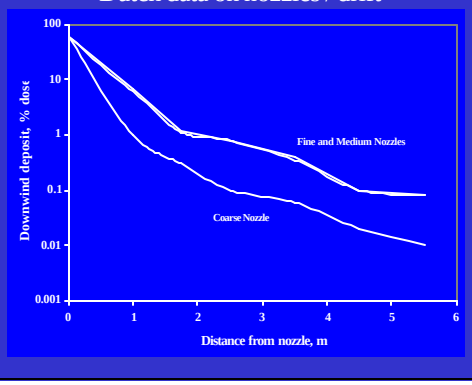
* **Field related factors**
  Crop, distance and direction to sensitive area, etc.

* **Sprayer related factors**
  Height, droplet size spectra, droplet velocity spectra, ground speed, air entrainment, supplemental air flow, etc.

* **Atmospheric related factors**
  Wind speed, direction, turbulence, humidity, stability, temp., etc.

Comp. and elect. in ag. 1997. 19:1-22.

Dutch data on nozzles / drift



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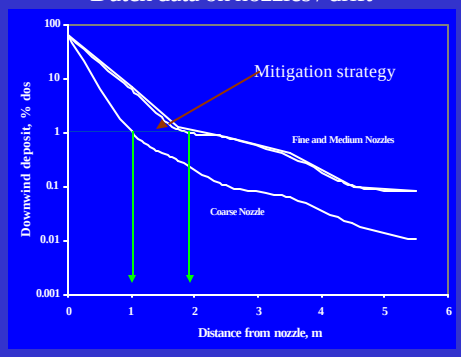

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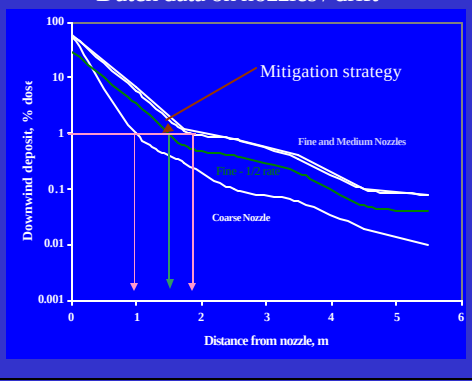


Local Environmental Risk Assessment for Pesticides (U.K.)

- Designed to protect waterways from drift fallout.
- Specifies an unsprayed buffer zone (UBZ) based on the width of the waterway, the dose of chemical applied and the performance of the sprayer.
- Assigns a "star rating" of * , **, or *** to the specific sprayer being used.

LERAP Buffer Zones in meters for a < 3 m wide waterway.

Sprayer Rating	Full chemical rate	3/4 chemical rate
*	4	2
**	2	2
***	1	1

LERAP Star Ratings

"Standard Treatment" of a 11003 nozzle @ 43 psi

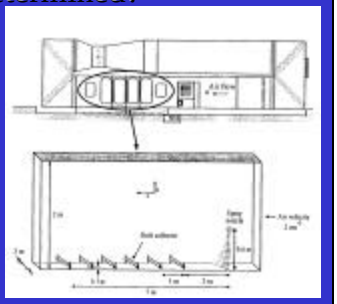
Relative Drift	Sprayer Rating
50 - 75%	*
25 - 50%	**
< 25%	***

How is the relative drift determined?

1. A laboratory wind tunnel is used to simulate a spray boom in a light wind.

2. A tracer dye is sprayed and recovered from sampling strings.

3. Recovered dye amounts are compared to those of the standard nozzle.



Models / experiments looking at droplet size, wind velocity and droplet velocity (OSU).

Drift distance of a droplet

Droplet dia. (µm)	Wind vel. (m/s)	Droplet vel. (m/s)	Drift (m)
80	0.5	15	1.2
100	1.0	10	1.6
200	4.0	5	1.8

Reichard et al. 1992. Trans. ASAE 35(5):1401-1407)

Why smaller droplets?
Deposition & Efficacy.

Label rate (l/ha)	Spray vmd (µm)	Required dose (l/ha)
	200	1.05
1.75	240	1.69
	395	1.81

(95% weed control w/ MCPA+klopyralid+fluroxipyr - data from SLU Uppsala)

Why smaller droplets?
Deposition & Efficacy.

Label rate (g/ha)	Spray vmd (µm)	Required dose (g/ha)
	200	1.38
7.5	240	1.70
	395	8.90

(95% weed control w/ tribenuronmetyl+fluroxipyr - data from SLU Uppsala)

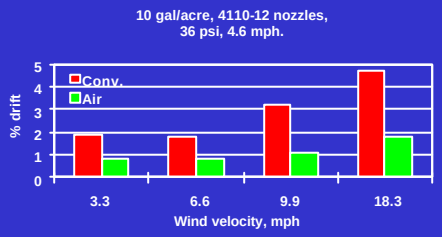
Example case: supplemental air

Adjustment of the air assistance

Adjust to:

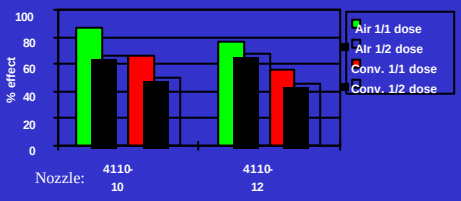
- wind speed
- nozzle size
- plant density
- crop height
- target location

Airborne drift at various wind velocities



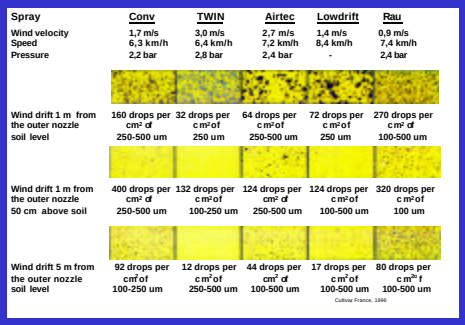
Air assisted spraying at 18.3 mph wind produces equivalent drift to conventional spraying at 3.3 mph wind.

Efficacy of air-assisted application: Weed control in sugar beets



Air assisted spraying at 1/2 rate produces equivalent efficacy to conventional spraying at 1/1 rate.

Images of near-boom spray drift



Spraying periods

Average increase in number of spraying periods of minimum 3 hours on a locality in England (1970-1989).

Month	Wind velocity 4.1 m/s*	Wind velocity 8.75 m/s**	Extra capacity spraying with TWIN, %
January	0	0	0
February	1	1	0
Marts	3	9	200
April	13	35	170
May	26	74	185
June	37	82	122
July	40	91	128
August	44	91	107
September	30	68	127
October	15	34	127
November	2	6	200
December	0	0	0

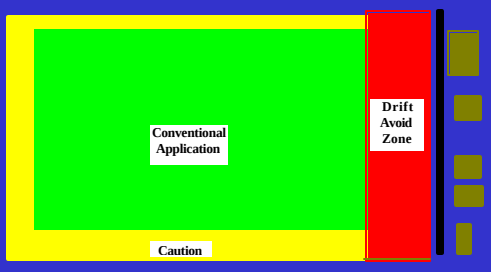
* 4.1 m/s: max. wind velocity spraying conventional
** 8.75 m/s max. wind velocity spraying TWIN SYSTEM

Nottingham Weather Center, UK, 1990

Spraying is not a static problem!

- Rate controllers are very common.
- Flow rate changes with ground speed
- Most vary pressure to accomplish this.

Off-target drift control



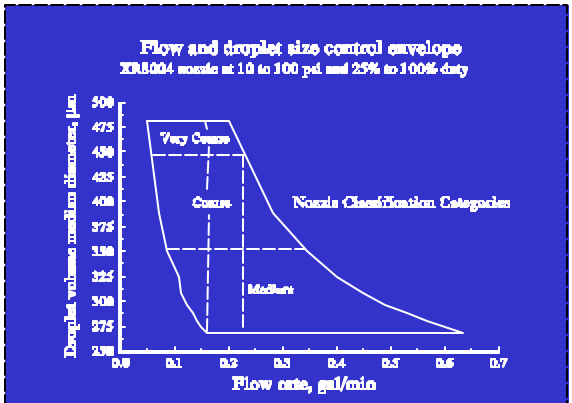
Example case: Blended pulse technology

- Provides rapid and independent rate and droplet size control.
- Allows applicator to adjust to immediate, local conditions.
- Provides accountability
- In development: on-board drift models and control.

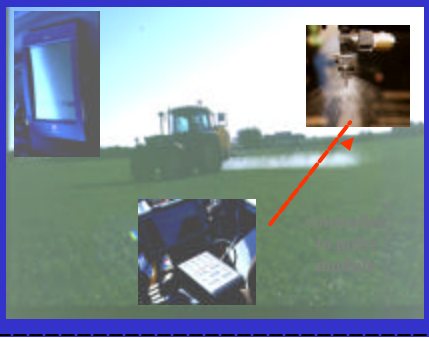
Pulsing the nozzles:

- Allows you to widely adjust the application rate (up to 8:1) without changing supply pressure.
- Maintains good pattern and uniformity.
- Gives an almost instant change.
- Allows wide pressure change to control droplet size and velocity.

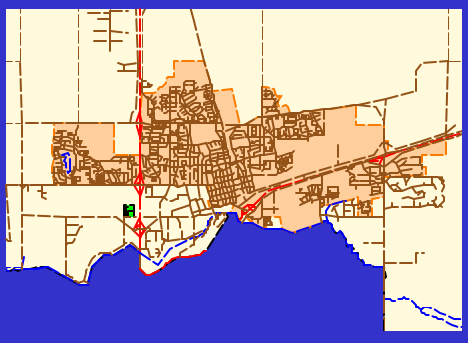
Pulsed Emissions from Nozzles



Electronic interfacing on a control system

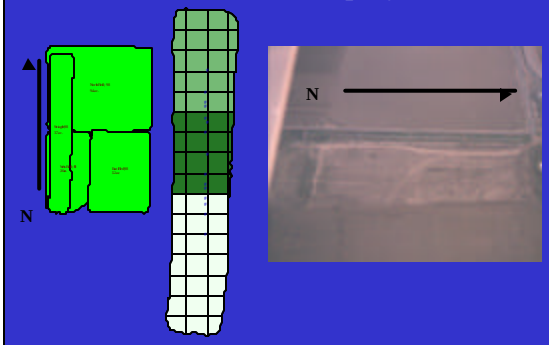


Test farm south of Davis, CA



Western Center for Agricultural Equipment

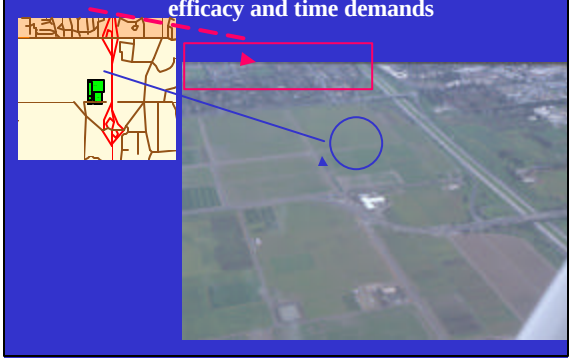
Test field for this project

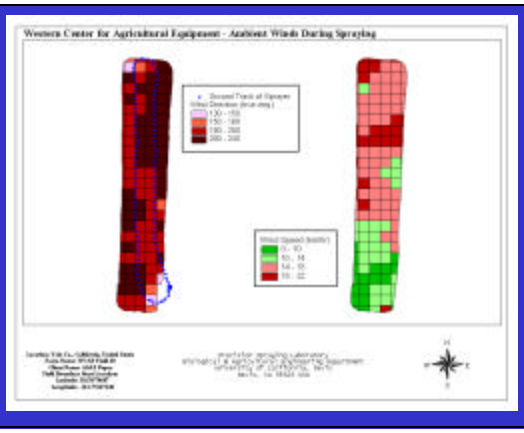


Self propelled Patriot (60 ft m boom width)

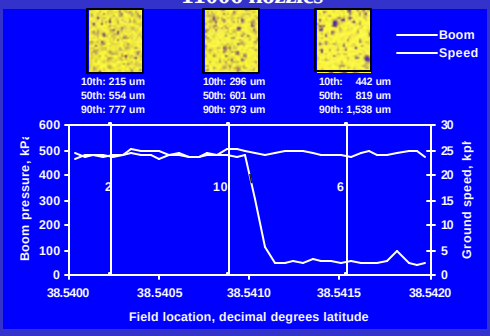
The ground truthing

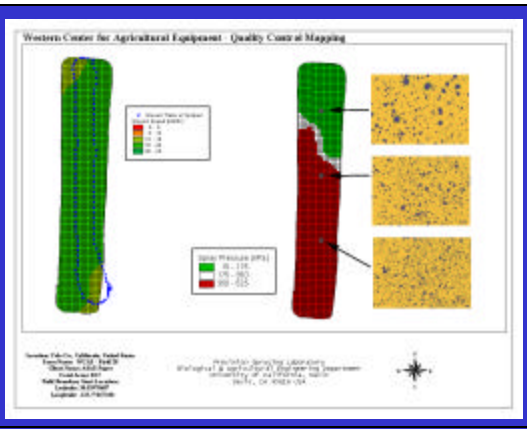
Spraying near a sensitive area with weather, efficacy and time demands





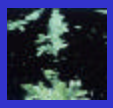
Constant rate, blended pulse flow control, 11006 nozzles



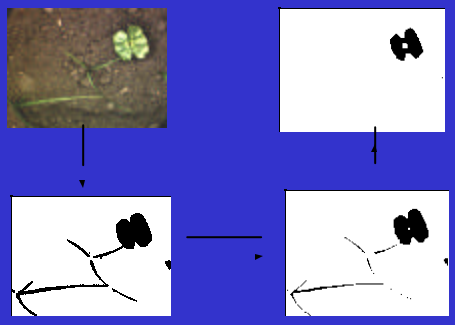


Mechanical shields - proven technology

Tracking and spray width control



Process for image analysis



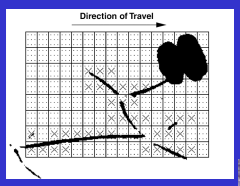
Micro boom and individual nozzles

(One nozzle per cell)

Fast valves for flow control

Micro-nozzles for dosing

Target plants



Spraying out the micro-map

Sensing: Sparse targets along a roadside

Solution: Video detection of targets

Conclusions

- Drift mitigation is a balance of controllable factors to achieve reliable drift control.
- Drift mitigation should be based on robust, engineering principles which consider all aspects of the pesticide application process.
- Technology and data supporting drift mitigation with targeted application and rate reduction are in place.